7.5/7.5

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413 – 55

Assignment 2
8 July 2019

great

1.1 The following present sample mean, standard deviation, minimum, maximum, range, skewness, excess kurtosis for simple returns and log returns on Netflix stock and S&P composite index from 2 Jan 2009 to 13 Dec 2013:

Simple returns

	mean	sd	min	max	range	skew	kurtosis
nflx	0.0027334277	0.03854069	-0.348957	0.422235	0.771192	0.9304588	21.884230
sprtrn	0.0006445763	0.01226270	-0.066634	0.070758	0.137392	-0.1557513	4.091064

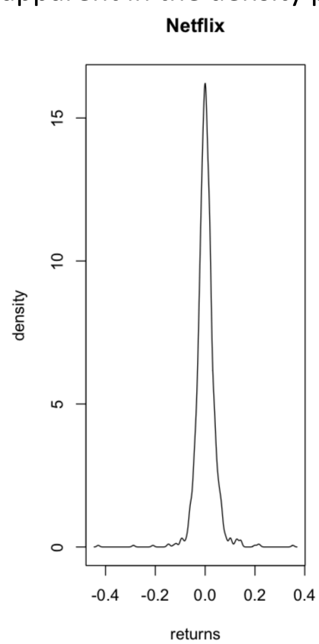
NFLX experienced greater mean return than, broader range of returns than, 10x the variance (3x the standard deviation) of S&P. NFLX return distribution is positively skewed while S&P return distribution is negatively skewed. Both have fat tails; NFLX much more so than S&P.

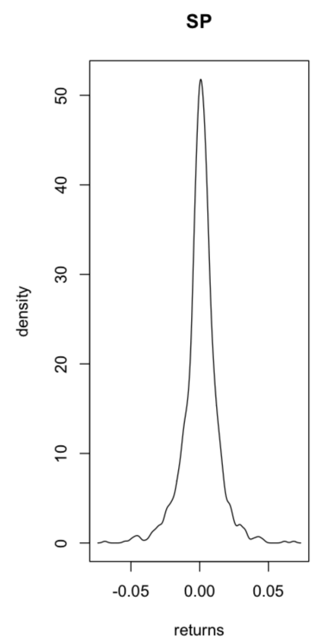
Log returns

	mean	sd	min	max	range	skew	kurtosis
nflx	0.0019960536	0.03837331	-0.42917959	0.35222958	0.7814092	-0.4346916	23.549867
sprtrn	0.0005692027	0.01227226	-0.06895787	0.06836681	0.1373247	-0.2669580	4.096303

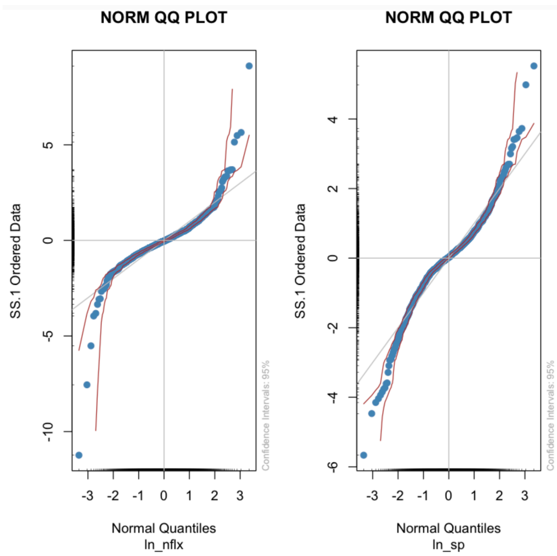
NFLX experienced greater mean return than, broader range of returns than, 9.3x the variance (3x the standard deviation) of S&P. Both log return distributions are negatively skewed. NFLX still has fatter tails than S&P.

1.2 The density plots of Netflix and S&P log returns are unimodal and appear to be somewhat normal, thought high peaked and thin shouldered with fat tails is somewhat apparent in the density plots.





Both plots' kurtotic distribution is more apparent in their QQ plots. In both cases, observations measured on the y-axis appear outside +/- 3 SD boundaries of the x-axis. For Netflix these points are as far as -11 SDs and +9 SDs where in the normal distribution they would appear at a fraction over 3 SDs from the center. A moderated degree of kurtosis is found in the S&P plot where extreme points are found -5.8 SDs and more than +5 but less than +6 SD from the mean.



1.3 The sample mean of the log returns of Netflix stock is ~20 bp (0.001996054). We do not know the population variance and so use the t-test. As shown below, the t-test yields a test statistic of 1.8449 and a p value of 0.06528 meaning that one cannot reject the Null hypothesis that the true or population mean log return equals zero at the 5% level or with confidence > 95%. If one were to reject the null hypothesis that Netflix log return is zero, the p-value suggests the probability of a Type 1 error is 6.5%.

```
        One Sample t-test

data:  rtn$nflx
t = 1.8449, df = 1257, p-value = 0.06528
alternative hypothesis: true mean is not equal to 0
95 percent confidence interval:
 -0.0001264844  0.0041185915
sample estimates:
  mean of x
0.001996054
```

suggests symmetry

1.4.1 The pairwise association between the sample log returns of Netflix stock and S&P index can be described in many ways, but succinctly by the correlation coefficient which = 0.2499 as shown in the Pearson's product-moment output below. This figure represents whether there is a linear relationship between the two sets and usually is not robust to outliers. This output also demonstrates that the null hypothesis that the correlation between Netflix and S&P log returns is zero may be rejected at the 0.1% level or with confidence > 99.9%.

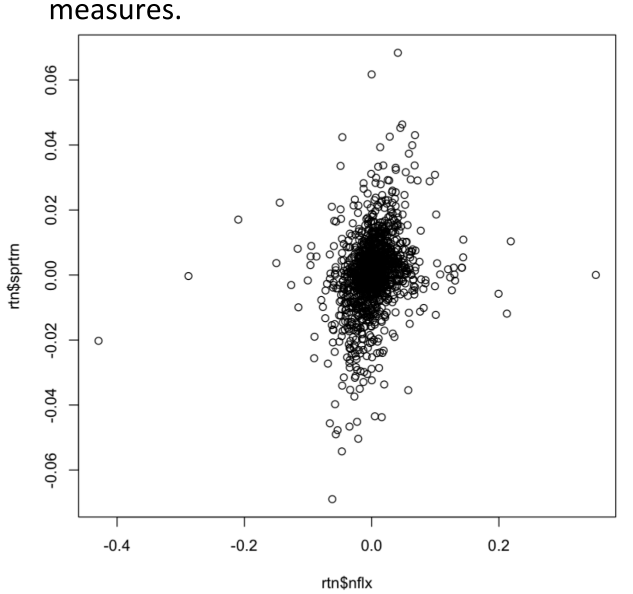
```
        Pearson's product-moment correlation

data:  rtn$nflx and rtn$sprtrn
t = 9.148, df = 1256, p-value < 2.2e-16
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.1973911 0.3010444
sample estimates:
      cor
0.2499336


        Kendall's rank correlation tau

data:  rtn$nflx and rtn$sprtrn
z = 11.656, p-value < 2.2e-16
alternative hypothesis: true tau is not equal to 0
sample estimates:
      tau
0.2193945
```

From the plot below, one can see a relationship whose slope here appears fairly steep though one needs to be careful as the ratio of the axes distorts. Were it not for the extreme Netflix returns, (-43% to +35%), the plot might show a more random relationship in accordance with the low correlation. Points where S&P returns are zero and Netflix are -30% and +35% are outliers that might also confound correlation measures.



Kendal's tau = 0.2194 might be helpful with these points and other outliers. Tau provides a sense of concordance versus discordant pairs of observations which is very low and yet as with correlation, we can reject the null hypothesis that the measured Kendal's tau is zero at the 99.9% confidence level. Very similar p-values for both measures, but again this does not increase confidence in association, just confidence in measured values are not zero. This t-test employed here is robust to modest departures from normality.

The usefulness of comprehending associations between individual stock returns and index returns allows us to comprehend the extent to which individual stock returns are driven by broader market returns.

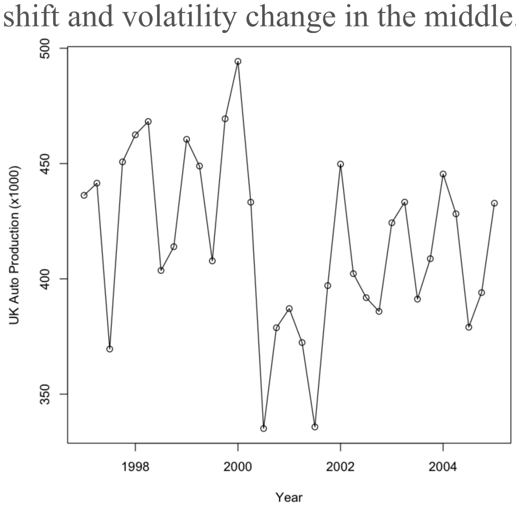
2.1 To test Netflix log returns symmetry, we define null hypothesis H_0: skewness = m_3 = zero and alternative hypothesis H_a: m_3 != zero, compute the test statistic = sample skew / sqrt(6/n) which is -6.2943 which is less than -1.96, which means one cannot reject the null hypothesis that the distribution of Netflix log returns is symmetric, skew = m3 = 0. The p-value for this test is 3.08e-10 which enables us to reject H_)with confidence > 99.9%.

2.2 To test for kurtosis in the Netflix log returns set, define the null hypothesis H_0: K = 3 and alternative hypothesis H_a: K != 3. This is equivalent to testing the null hypothesis H_0: excess kurtosis = zero and the alternative hypothesis H_a: excess kurtosis != zero. Compute the test statistic = sample excess kurtosis / sqrt(24/n) which is 170.5 well in excess of 1.96 enabling one to reject the null hypothesis that the distribution of Netflix log returns has non-zero kurtosis.

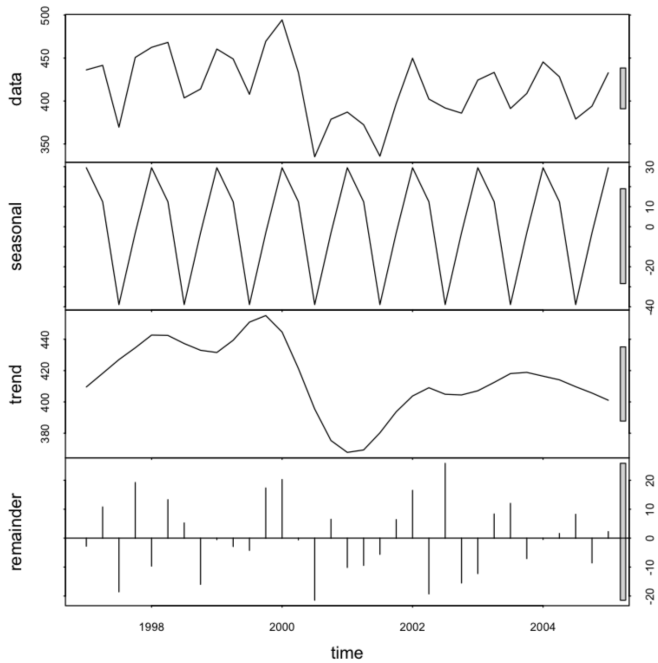
2.3 95% confidence interval for Netflix daily log returns was shown above in (1.3): lower confidence level = -0.0001264844 and upper confidence level = 0.0041185915. These figures represent the 95% of the t-distribution of the standard error of the sample mean around the mean of the sample distribution: mean +/- sqrt(var/n) * qt(1-c1/2) with n-1 DOF.

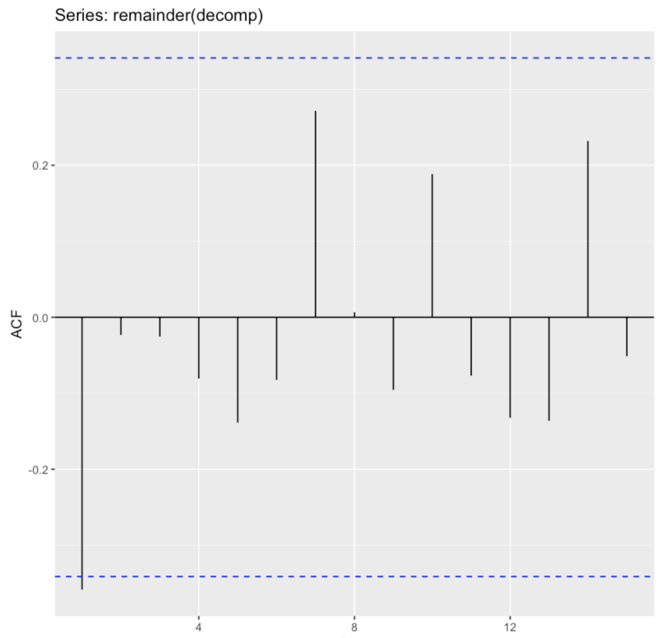
2.4 "If we chose to hold Netflix stock for 1259 days, we could expect that 95 percent of the time, the mean of 1258 daily returns would be between -1 bp and +41 bps. When I say 95 percent of the time that means pick at random 100 different sequentially arranged days and for 95 of those randomly selected 1259 day periods, you would have this mean return range."

3.1 These Netflix log returns have seasonality: 8 years of data, 8 down spikes, each with 3 intervening points. There are 9 up spikes, but for each there is less predictable number of intervening points. If one cheats and looks at the data, the 3rd quarter is a seasonal low. One can almost make out alternating years where 1H and 4q contain the seasonal high. The 11 points on LHS have a mean that appears to be just below their initial point. The 11 points on the RHS have a mean that is between their initial point and end point. In the middle is the high for the series, a collapse to lows for the series, a relapse and recovery. I would describe the series as nonstationary due to the predictable seasonality and the level shift and volatility change in the middle.



3.2 Seasonality is additive for holt() and thus a stable repetition. Looking at remainder, all but lag=1 is within the 95% confidence interval of the correlogram.





One can see the 1, 5, 9, 13 lagged remainder (every 4th) are similar in magnitude which suggests a multiplicative version of STL (via transformation) might help in obtaining multiplicative seasonality. The length of the relative scale bars on RHS of trend and seasonal plots appear to indicate trend strength stronger than seasonal and the figures bear this out. This is borne out when calculations are performed: remainder variance is only 19.1% of combined remainder and seasonal variances and 23.5% of combined remainder and trend variances.

3.3 Additive damped trend method applied to seasonally adjusted car sales data are represented here. Low and high 95 are the grey bounds and low and high 80 the purple.

```
Forecasts:
        Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
2005 Q2       402.9247 370.9625 434.8869 354.0427 451.8067
2005 Q3       402.8985 362.4872 443.3098 341.0948 464.7022
2005 Q4       402.8751 355.4970 450.2532 330.4166 475.3337
2006 Q1       402.8543 349.4089 456.2997 321.1166 484.5919
2006 Q2       402.8357 343.9440 461.7274 312.7686 492.9028
2006 Q3       402.8192 338.9432 466.6952 305.1292 500.5091
2006 Q4       402.8045 334.3053 471.3036 298.0440 507.5649
2007 Q1       402.7913 329.9614 475.6213 291.4075 514.1751
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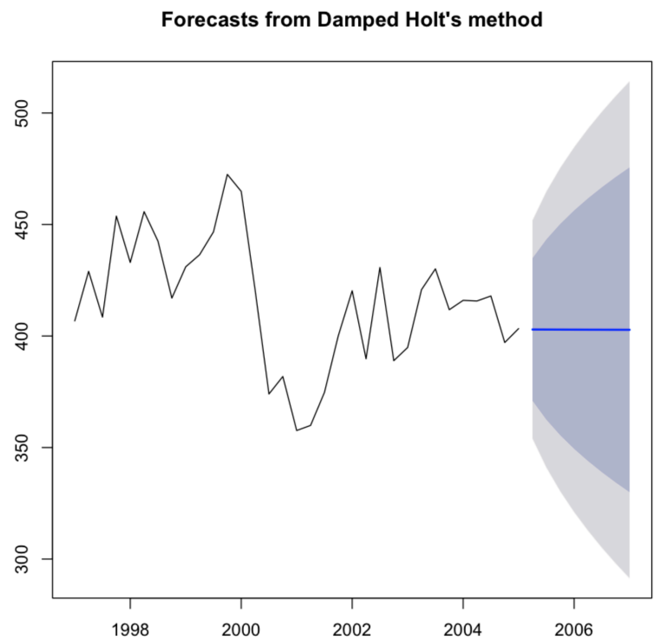


One can barely discern a slope in the forecast blue line, but from these figures you can see the point forecast declines from 402.92 in Q2'05 to 402.79 in Q1'07 based upon phi dampening of 0.89 which is roughly middle of the practical range, and beta of trend smoothing = zero which employs the most recent trend. With phi set to less dampening =.99, the forecast starts at 402.937 and rises to 402.977. Without dampening, the forecast begins 403.10 and rises to 403.94. (None of these Q2 starting points for the forecast include the seasonal factor which would contribute an additional 12.48 to Q2 production.

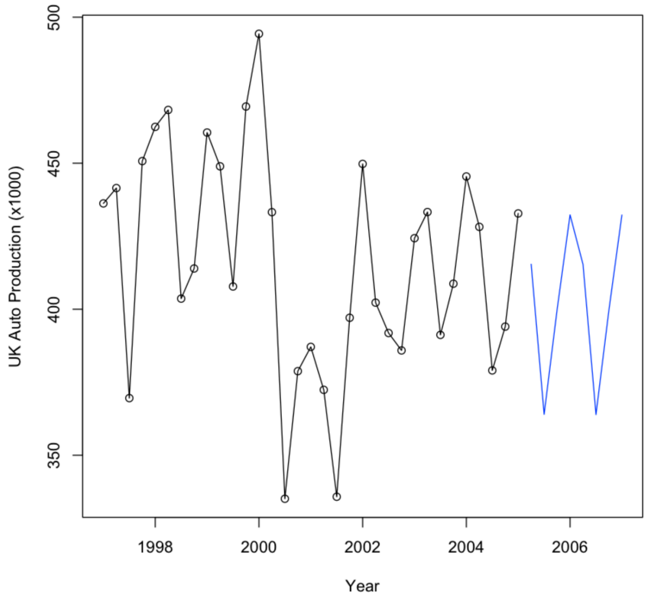
3.4-3.5 I am confused on the difference between these questions.
Re-seasonalizing these forecasts is a simple matter of adding back 8 quarters of the additive seasonality of the Holt model, which is a repetition of 4 quarters 2 times: 12.48, -38.89, -3.05, 29.46, 12.48, -38.89, -3.05, 29.46, to the mean of forecasts for each period. These are the mean forecasts:

	Qtr1	Qtr2	Qtr3	Qtr4
2005		402.9247	402.8985	402.8751
2006	402.8543	402.8357	402.8192	402.8045
2007	402.7913			

and these the re-seasonalized:

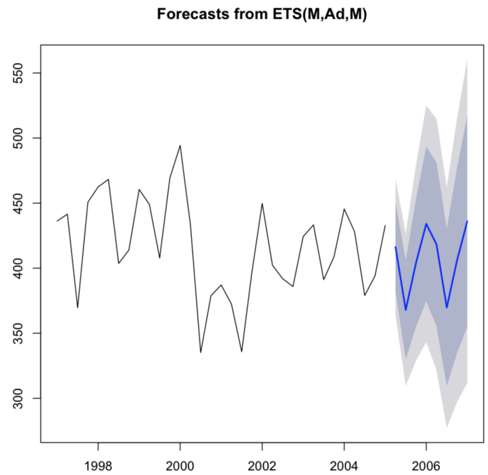
	Qtr1	Qtr2	Qtr3	Qtr4
2005		415.4065	364.0043	399.8258
2006	432.3160	415.3175	363.9250	399.7551
2007	432.2531			

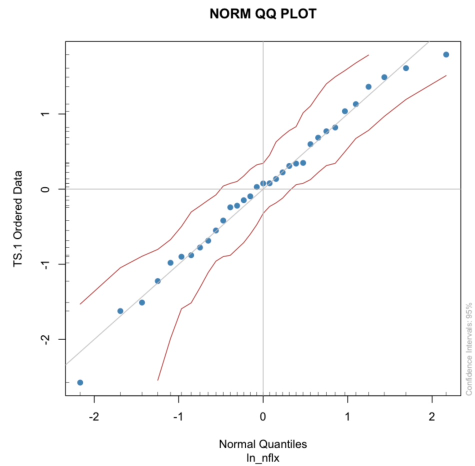
Plotted here in blue:



The parameters of this forecast are the same as the original model considering that seasonality is additive in the original model and does not change here. Alpha=0.7736, Beta = 1e-04 ~ zero, and Phi=0.891 minimize RMSE which is 22.97. RMSE is computed from the errors of in sample observations versus in sample forecasts and so should not change if we re seasonalize the forecast by adding back seasonal adjustments.

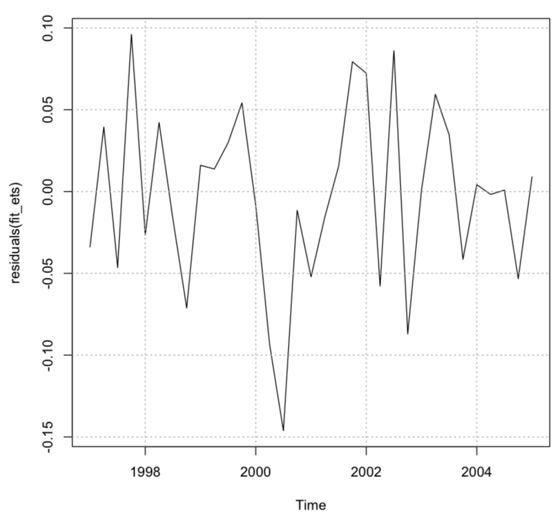
3.6 I would select a multiplicative error model with damped additive trend and multiplicative seasonality. Mutliplicative selection for errors and seasonality is based upon the impact that large level shifts will have on model accuracy under an additive regime for either parameter. I would prefer proportional errors and seasonality in that case. As mentioned in assignment 1, I prefer dampended models as I regard them as a form of regularization which improves the generalization of the model. The specifics of this model, employs alpha 0.766, (collecting 77% of the most recent level), zero beta which desensitizes slope to recent changes, and phi = 0.97 which provides less dampening regularization.

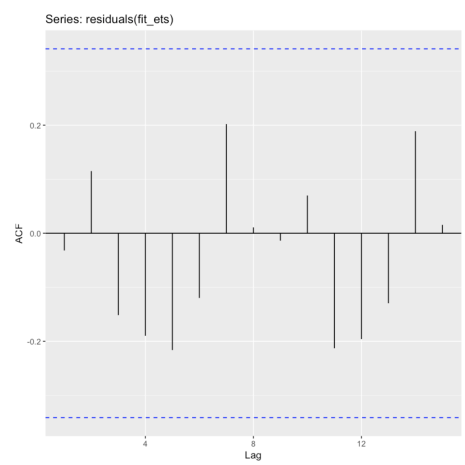




good

A QQ plot of the residuals reveals that it is relatively normal. Thus I feel faily good about the distribution of errors as RMSE is reduced from 22.97 in the holt() model above to this ets() model where RMSE = 22.63. This only cause for concern for this model is how the residuals are distributed through time and across rapid shifts in level as experienced through the 2000-2002 period as shown below. So this model may experience some issue with accuracy through similar shifts in the future, though better than an additive error model. Autocorrelation of the residuals via correlelogram (below) indicate that most of what we are seeing in the LHS plot is white noise.





Point forecasts from the ets() model with MAM model are:

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
2005 Q2	416.2463	381.9944	450.4982	363.8625	468.6301
2005 Q3	367.9624	329.8092	406.1156	309.6121	426.3127
2005 Q4	404.0385	354.9979	453.0791	329.0373	479.0396
2006 Q1	434.0753	374.6929	493.4578	343.2577	524.8930
2006 Q2	418.2838	355.2364	481.3311	321.8611	514.7064
2006 Q3	369.7067	309.2884	430.1250	277.3048	462.1085
2006 Q4	405.8934	334.7777	477.0091	297.1313	514.6555
2007 Q1	436.0054	354.7954	517.2154	311.8055	560.2053

3.7 As mentioned the RMSE of this ets() model is 22.63 and holt() model is 22.97. The holt() model error is greater, and thus gives worse in sample fits. Yet, holt() it is a much simpler model, e.g. additive in seasons. The AIC of the holt() model is 334.25 versus AIC of ets() which is 341.76. So the ets model may not generalize as well out of sample.

3.8 Setting ets() model = "ZZZ" for autofocus, the RMSE of the best model 22.65 is worse than the RMSE = 22.63 of the model = MAM with damped=TRUE as chosen in 3.7 above. Autofocus selects multiplicative error, no trend, and multiplicative seasonality; so it is equivalent to "MNM" and that is not surprising given what beta = zero and dampening ~1 we found when using "MAM. I tried a variety of models and none were better than MAM in terms of RMSE. MAM with dampening provided the lowest RMSE.

4.0

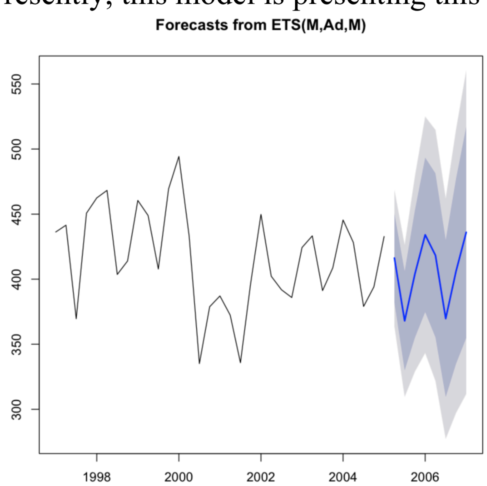
Report

Our business experiences regular seasonality. 3rd quarter the worst every year since 1997 and in alternating years we have our best quarter in either 1st half or 2nd half. Thus, any model we employ needs to contribute to our forecasts with seasonal awareness. Good news is that most models we consider have this seasonal awareness.

During an economic downturn when UK car production declines precipitously, 32% in 2000-2002, we need forecasts which can adjust proportionately. Presently our 3rd quarter production is 39 million units less than 2nd quarter on average. If production declines from 2000-2002 were to repeat, we would want our forecast production in the 3rd quarter to account for the broader 32% decline as well.

The model we are considering has this proportionality for seasons and for its forecast error. I recommend this model.

Presently, this model is presenting this forecast plot and these figures for production.



	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
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2006 Q1	434.0753	374.6929	493.4578	343.2577	524.8930
2006 Q2	418.2838	355.2364	481.3311	321.8611	514.7064
2006 Q3	369.7067	309.2884	430.1250	277.3048	462.1085
2006 Q4	405.8934	334.7777	477.0091	297.1313	514.6555
2007 Q1	436.0054	354.7954	517.2154	311.8055	560.2053

No forecast is perfect. So the dark and light grey bands provide a degree of confidence around the main forecast figures in dark blue.

to many numbers ~~to~~ se only what is needed